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(54) A gas-liquid contacting apparatus

(57) A gas-liquid contacting apparatus 1 comprises an upwardly extending casing 2 having a number of frothing trays 6 to 8 extending across the casing interior at different levels, and perforated, packing trays 14, 16 partitioning the spaces between the frothing trays 6 to 8 into an upper packing section 18, 20 containing respective gas-liquid contacting packings 26, 28 and respective lower frothing sections, 22, 24.

Each frothing tray may be divided into - e.g. four - spaced portions spanning the width of the casing - Fig 2 (not shown).

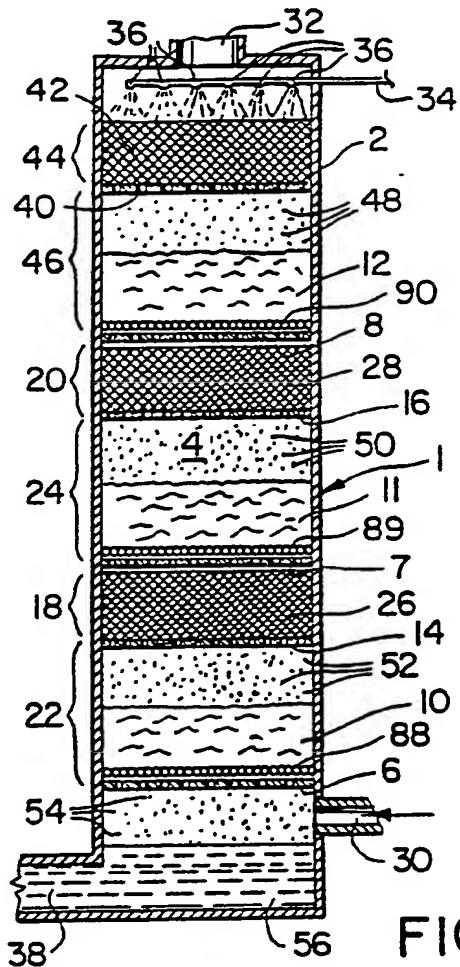


FIG. I

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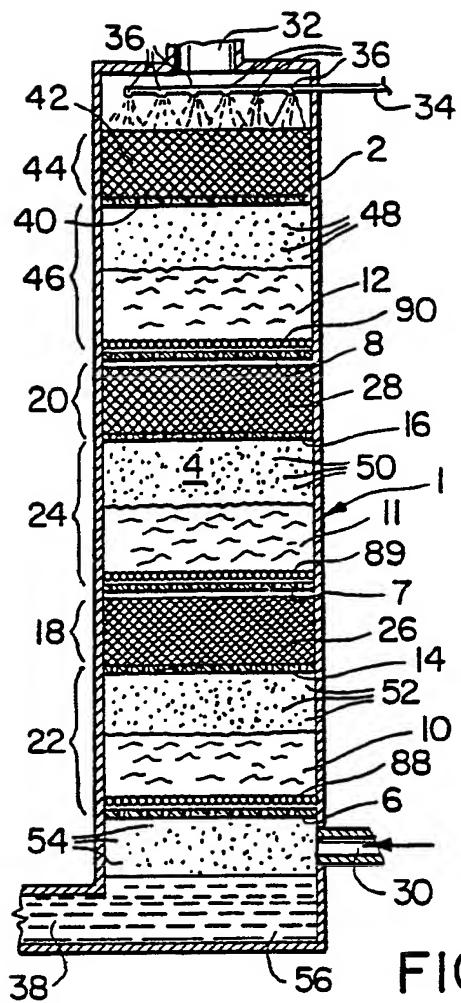


FIG. 1

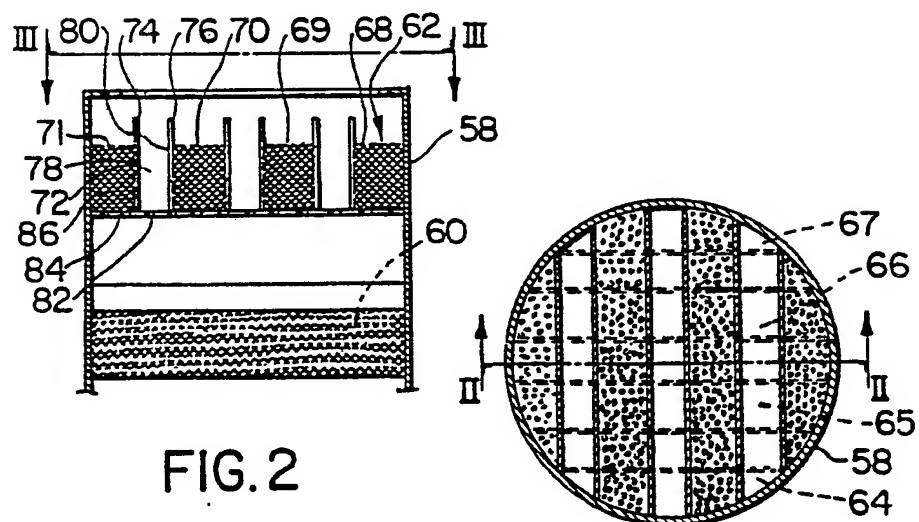


FIG. 2

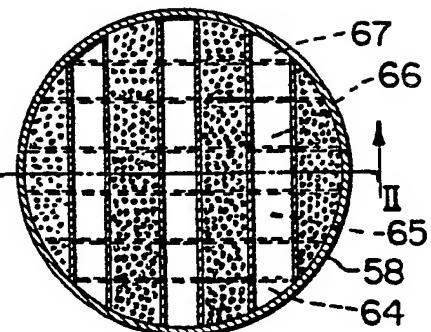


FIG. 3

A GAS-LIQUID CONTACTING APPARATUS

1 This invention relates to a gas-liquid
contacting apparatus.

5 There are two types of gas-liquid contacting
apparatus for use, for example, in distillation and
absorption, and these are:

- i) sieve or perforated trays which offer low efficiency and low cost, and
- ii) random or ordered packed beds which are more efficient but which are also more expensive.

10 Sieve trays and packings are used extensively in gas-liquid contact applications such as distillation. In general, sieve trays are considered less efficient than the packings. This is in part due to the fact that there is a large space above the froth 15 on the sieve tray that is not active for mass transfer. If we consider a typical froth height of 150 mm and a tray efficiency of 60%, then the height equivalent to a theoretical plate (HETP) would be 250 mm, a value close to that for the high performance structured packing.

20 However, the vapor-liquid disengagement space above the froth is necessary for maintaining hydraulic stability of the tower. This space is about 2-3 times the froth height and as a result the HETP for a sieve tray is about 700 mm. This HETP is similar to that for a low 25 efficiency random packing but considerably higher than that for a structured or ordered packing.

There is a need for a gas-liquid contacting

1 apparatus which makes use of sieve or frothing trays
and yet has high mass transfer rates and high
gas-liquid throughput.

5 According to the present invention there is
provided a gas-liquid contacting apparatus, comprising:

a) an upwardly extending casing forming a flow
path for the flow of liquid downwardly therethrough and
flow of gas upwardly therethrough,

10 b) a series of frothing trays extending across and
partitioning the flow path in the casing at different
levels, each tray being perforated for distributing
liquid thereacross which has been frothed by upwardly
flowing gas therethrough,

15 c) for each pair of frothing trays, a perforated,
packing tray partitioning the portion of the flow path
of the casing therebetween to provide a flow path
packing section immediately beneath one of the frothing
trays, and a flow path frothing section immediately
above the lower one of those frothing trays, and

20 d) gas-liquid distributing packings in the packing
section.

In some embodiments of the present invention an
uppermost packing section is provided in the casing
above the level of the uppermost frothing section, and
25 gas-liquid distributing packings are provided in the
uppermost packing section.

Each frothing tray may comprise a plurality of

1 spaced portions spanning the width of the interior of
the casing, with the portions of one frothing tray
traversing the portions of adjacent trays, for each
space, between two portions of a frothing tray, a
5 downcomer may be provided leading therefrom, each
downcomer having perforated side walls and an
impermeable lower wall, each packing tray then
comprises a plurality of perforated, packing tray
portions each closing a packing section beneath a
10 frothing tray portion which is bounded by at least one
downcomer, perforated side wall, and the gas-liquid
distributing packings are then in each packing section
beneath each frothing tray portion.

In some embodiments of the present invention,
15 fluid permeable, gas distributing means are provided
for each frothing tray, each fluid permeable, gas
distributing means being adjacent the top side of the
tray associated therewith for, in operation, breaking
up any bubbles forming on the pores of that frothing
20 tray.

Each fluid permeable, gas distributing means
may be fibrous or filamentary material in open mat,
felt or woven form.

Each fluid permeable, gas distributing means
25 may be an open mesh.

In the accompanying drawings which illustrate,
by way of example, embodiments of the present
invention,

1 Figure 1 is a diagrammatic, sectional side view
of a gas-liquid contacting apparatus,

5 Figure 2 is a diagrammatic, sectional side view
along II-II, Figure 3 of a portion of a different
gas-liquid contacting apparatus to that shown in Figure
1, and

10 Figure 3 is a diagrammatic, sectional plan view
along III-III, Figure 2.

15 Referring now to Figure 1 there is shown a
gas-liquid contacting apparatus, generally designated
1, comprising,

20 a) an upwardly extending cylindrical casing 2
forming a flow path 4 for the flow of liquid downwardly
therethrough and flow of gas upwardly therethrough,

25 b) a series of frothing trays 6 to 8 extending
across and partitioning the flow path 4 in the casing 2
at different levels, each tray 6 to 8 being perforated
for distributing liquid thereacross which has been
frothed, to form froths 10 to 12 respectively, by
upwardly flowing gas therethrough,

30 c) for each pair of frothing trays 6, 7 or 8,
8, a perforated packing tray, 14 and 16 respectively,
partitioning the portion of the flow path of the casing
2 therebetween to provide a flow path packing section,
18 and 20 respectively, immediately beneath the upper
one, 7 and 8 respectively, of the frothing trays, and a
flow path frothing section, 22 and 24 respectively,

1 immediately above the lower one, 6 and 7 respectively,
of those frothing trays, and

d) gas-liquid distributing packings 26 and 28
in the packing sections 18 and 20 respectively.

5 The upwardly extending casing 2 has a gas inlet
30, a gas outlet 32, a liquid inlet pipe 34 feeding
liquid spray nozzles 36 and a liquid outlet 38.

The packings 26 and 28 may be random packings
or may be structured to form an ordered bed.

10 In this embodiment, a further, perforated,
packing tray 40 is provided supporting a packed bed 42
in a packing section 44 beneath the liquid spray
nozzles 36, and providing a frothing section 46 above
the frothing tray 8.

15 In operation, gas is fed into the casing 2
through the inlet 30 while liquid is fed along the pipe
36 to the nozzles 36. The liquid is sprayed on to the
packings 42 to trickle downwardly therethrough in a
well distributed manner and emerge therefrom as
20 droplets 48 which fall on to the frothing tray 8. The
droplets 48 falling on to the frothing tray 8 form a
liquid level thereon some of which is frothed, to form
froth 12, by the gas passing upwardly through the
casing 2 from the inlet 30. Some of the liquid on the
25 frothing tray 8 escapes through the perforations to
form droplets well distributed over the packings 28.

The droplets trickle downwardly through the

1 packings 28 and emerge as droplets 50 which fall on to
the frothing tray 7 to form a liquid level thereon some
of which is frothed, to form froth 11, by the gas
passing upwardly through the casing 2. Some of the
5 liquid on the frothing tray 7 escapes through the
perforations to form droplets 52 which trickle
downwardly through the packings 26 to fall as droplets
on the frothing tray 6 where a liquid level is formed
and froth 10 is made by upwardly flowing gas. Liquid
10 escaping through the perforations in the frothing tray
6 forms droplets 54 which collect as liquid 56 which
forms a liquid, draining seal.

It will be seen that gas passing upwardly
through the casing 2 is brought into intimate contact
15 with liquid passing downwardly therethrough because:

- i) the usually inactive space above a frothing tray
is used as a gas-liquid contacting section by
partitioning the casing 2 above each tray to form an
upper, packing containing section and a lower frothing
20 section,
- ii) the packings provide good distribution of the
droplets falling gently through the frothing sections
on to the frothing trays, and
- iii) the frothing trays provide good distribution of
25 the droplets falling through their perforations on to
the packings.

The result is that in a gas-liquid transfer

1 operation such as methanol-water distillation, the
apparatus according to the present invention can
achieve a combined efficiency for the frothing trays
and packings of, say, 135% compared with an efficiency
5 of, say, 65% for a low cost, conventional apparatus
containing only frothing trays where only a low
throughput is possible.

10 Furthermore, the efficiency and/or throughput
of an apparatus according to the present invention has
been found to compare favorably with the more expensive
apparatus containing only packed beds.

15 Also, when the gas flow is high, the packings
have been found to serve as de-entrainment sections
thus further improving the gas-liquid contact.

20 The provision of the extra packings 42 enhance
the distribution of the sprayed liquid from the nozzle
in addition to providing additional gas-liquid contact.

25 Tests to verify the present invention were
carried out in a 6 inch diameter column for the
distillation of methanol-water mixtures. A dual-flow
tray was used with 318 mm tray packing, 7 mm hole
diameter and 20% hole area combined with a 100 mm high
structured packing supplied by Glitsch, Inc. under the
trademark Gempack-350. The results indicated (1) a
tray efficiency of ~ 120-140% for an F-factor of 0.8 -
1.6 kg^½.s⁻¹.m^{-½} and (2) a maximum operable
F-factor = 1.8. This compares with an efficiency of

1 60% and maximum F-factor of 1.4 for a sieve or frothing
tray with similar tray spacing.

5 Tests have shown that the packing sections need
only be short, say 200mm, and so wall effects are
insignificant.

The gas may be in the form of a vapour.

10 The frothing trays 6 to 8 may be provided with
more perforations per unit area adjacent the casing 2
than at the center area of the trays 6 to 8 to provide
better distribution of liquid over the packings 26 and
28.

15 The apparatus according to the present
invention can be used in any distillation or absorption
processes. The packings may be random packings, e.g.,
rings, spheres or saddles or structured or ordered bed
packings, e.g. corrugated, rolled, screens or plates.

20 The apparatus according to the present
invention can be in the form of a new apparatus or a
modified existing apparatus.

25 - The combination of low cost and high efficiency
of an apparatus according to the present invention can
result in substantial savings in, for example, the
chemical, petroleum and paper industries.

Any known countercurrent tray arrangement, such
as, for example, dual-flow trays, and multiple
downcomer trays may be used.

Referring now to Figures 2 and 3, there is
shown a multiple downcomer apparatus.

1 In Figures 2 and 3 there is shown a portion of
a casing 58 containing two frothing trays generally
designated 60 and 62. Each tray is divided into four
spaced portions spanning the width of the interior of
5 the casing, that is portions 64 to 67 of tray 60, and
portions 68 to 71 of tray 62. The portions 64 to 67
traverse the portions 68 to 71 and any portions of any
further trays that are provided will primarily traverse
the portions of any adjacent trays.

10 The spaces between the tray portions, such as
space 72 between tray portions 70 and 71, form drainage
openings bounded by upstanding weirs 74 and 76 on the
tray portions 70 and 71. The drainage openings, such as
that formed by space 72 lead to spaced, parallel
15 downcomers each having perforated side walls such as
side walls 78 and 80, and an impermeable lower end
wall, such as end wall 82.

20 The spaces beneath the frothing tray portions
such as tray portion 71, and bounded by the perforated
side walls, such as side wall 78, are packing sections
and are each closed at the lower end by a perforated
packing tray portion, such as packing tray portion 84,
and are filled with packings, such as packings 86.

25 In operation, gas is passed upwardly through
the casing 58 while liquid is sprayed into the upper
end (not shown) of the casing 58 and gravitates
downwardly therethrough.

1 Some of the liquid descending on to, say, the tray portions 68 to 71 is foamed by gas passing upwardly through, say, the packings 86, so that foam will overflow the weirs, such as weirs 74 and 76 and

5 flow down the downcomers and through the perforated side walls, such as those designated 78 and 80. The remainder of the liquid descending on to, say, the tray portions 68 to 71 is distributed downwardly over, say, the packings 86.

10 Liquid entering, say, the packings 86 trickles downwardly to exit through the perforated plate 84 and fall onto the tray portions 64 to 67 where the same sequence of operations is repeated.

15 In different embodiments of the present invention, fluid permeable, gas distributing means 88 to 90, Figure 1, are provided for each frothing tray 6 to 8 respectively. Each fluid permeable, gas distributing means 88 to 90 being adjacent the top side of the tray, 6 to 8 respectively, associated therewith, for, in operation, breaking up any bubbles (not shown) forming on the pores (not shown) of that frothing tray 6 to 8.

20 The fluid permeable, gas distributing means 88 to 90 may be fibrous or filamentary material in open mat, felt or woven form.

25 The fluid permeable, gas distributing means may be an open mesh.

The fluid permeable, gas distributing means 88 to 90 achieve a more uniform froth formation on the trays 6 to 8.

5 The fluid permeable, gas distributing means 88 to 90 also assure a more uniform static head of liquid on the frothing trays 6 to 8 and a more uniform distribution of liquid across them. This gives a more uniform distribution of liquid gravitating downwardly through the
10 trays 6 to 8.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification and which are open to public inspection with this specification, and the
15 contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

25 Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving

the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

5

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any 10 accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

WE CLAIM:

1. A gas-liquid contacting apparatus, comprising:
 - a) an upwardly extending casing forming a flow path for the flow of liquid downwardly therethrough and flow of gas upwardly therethrough,
 - b) a series of frothing trays extending across and partitioning the flow path in the casing at different levels, each tray being perforated for distributing liquid thereacross which has been frothed by upwardly flowing gas therethrough,
 - c) for each pair of frothing trays, a perforated, packing tray partitioning the portion of the flow path of the casing therebetween to provide a flow path packing section immediately beneath one of the frothing trays, and a flow path frothing section immediately above the lower one of those frothing trays, and
 - d) gas-liquid distributing packings in the packing section.
2. An apparatus according to claim 1, wherein an uppermost packing section is provided in the casing above the level of the uppermost frothing section, and gas-liquid distributing packings are provided in the uppermost packing section. or claim 2
3. An apparatus according to claim 1, wherein each frothing tray may comprise a plurality of spaced portions spanning the width of the interior of the casing, with the portions of one frothing tray traversing the portions of adjacent trays, for each space, between two portions of a

frothing tray, a downcomer may be provided leading therefrom, each downcomer having perforated side walls and
5 an impermeable lower wall, each packing tray then comprises a plurality of perforated, packing tray portions each closing a packing section beneath a frothing tray portion which is bounded by at least one downcomer, perforated side wall, and the gas-liquid distributing
10 packings are then in each packing section beneath each frothing tray portion.

4. An apparatus according to any of the preceding claims, wherein fluid permeable, gas distributing means are provided for each frothing tray, each fluid permeable, gas distributing means being adjacent the top side of the tray associated therewith for, in operation, breaking up any bubbles forming on the pores of that frothing tray.
15

5. An apparatus according to claim 4, wherein each fluid permeable, gas distributing means may be fibrous or filamentary material in open mat, felt or woven form.
20

6. An apparatus according to claim 4, wherein each fluid permeable, gas distributing means may be an open mesh.

7. A gas-liquid contacting apparatus comprising a tube within which there is provided a transverse perforated frothing tray and a transverse perforated packing tray.
25

- 15 -

8. Apparatus according to claim 7 in combination with apparatus according to any of claims 1 to 6.

9. Apparatus substantially as hereinbefore described with reference to the accompanying drawings.

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